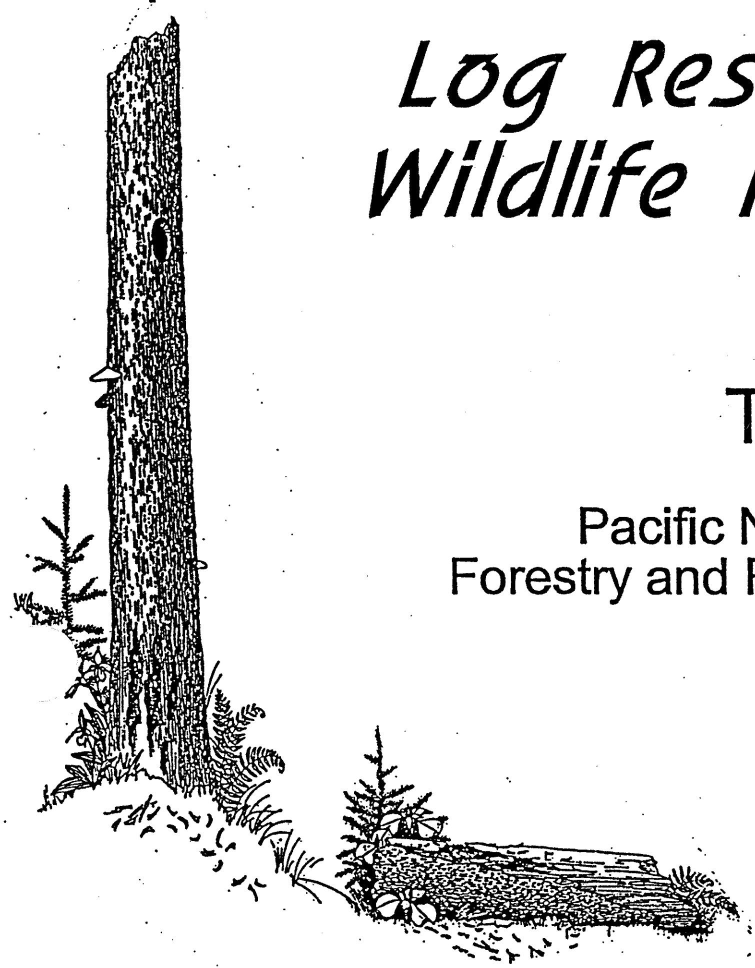

Log Resources and Wildlife Relationships

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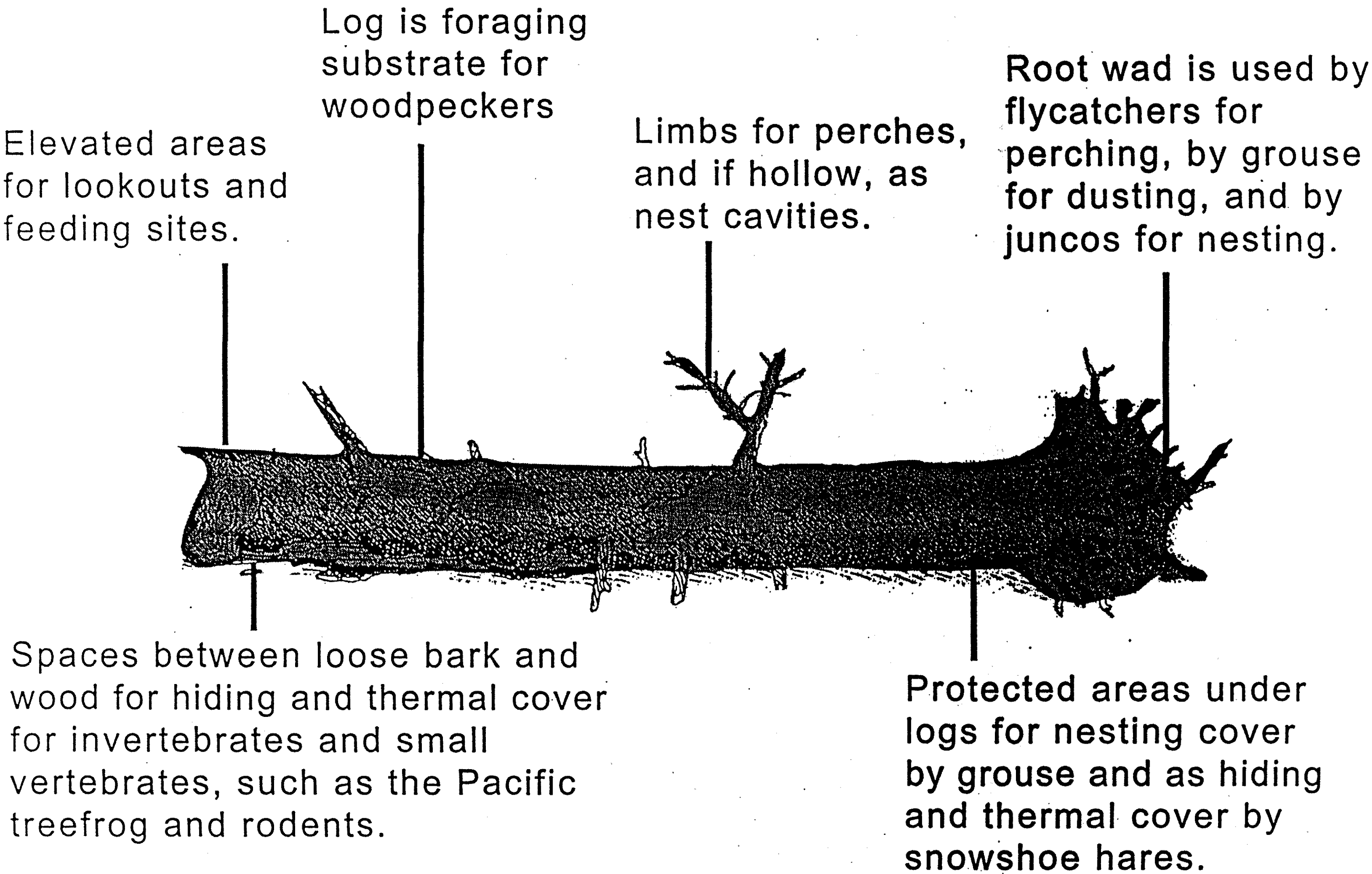
Ecological Processes and Functions

The natural fate of all living trees is to become part of the down-wood component on the forest floor. Characteristics of the living and dead standing component in a stand determine the species and physical attributes of the material that falls to the ground. Late-successional stands typically have large-diameter logs on the forest floor recruited from the wood resources in the standing trees through a variety of natural processes such as breakage; falling trees; and transport caused by snow-loading, windstorms, avalanches, debris flows, fires, and floods. Other natural processes such as the activity of insects and diseases that kill or physically weaken trees likewise contribute dead wood to the forest floor. All these factors can directly or indirectly result in death and falling of individual branches, tops, or whole trees. Stands or patches of trees and landscape-scale tree mortality are common events in the history of forest ecosystems. All of these mortality and decay processes are natural and necessary; they contribute to the nutrient reserves and physical and chemical characteristics of soils in healthy forests. Thus, dead wood in all its forms is a fundamental feature of healthy forests.

The "life" or persistence through time of dead trees, especially large ones, can last several decades. Over a period of possibly a century, logs serve as a source of organic and inorganic nutrients and chemical components in soil development. The constituents contributed by logs enrich the soil and improve its structural properties, allowing plant growth. Logs contribute to the water economy of a site and provide microhabitats that protect wood-dwelling organisms with moist, thermally stable, predator-protected niches in which to live. Logs in or near streams, ponds, or lakes provide structure for amphibians, beaver, mink, otter, and birds (Lofroth, in press; Maser and

Log structural features important to wildlife.



*after Thomas (1979)

Trappe 1984).

Organisms representing a broad array of plants, invertebrates, and vertebrates use log habitats in forests. From microscopic protozoa and fungi to wildlife and roots of large trees, down wood teems with life. Many of these organisms are connected by functional pathways that are partially or completely unknown. For both simple and complex plants and animals, down wood in all its forms represents a rich substrate on which they feed and live.

We use the term "logs" for down woody material such as trees, branches, or tops that have fallen to the forest floor. The minimum piece-size to qualify as a log has a large-end diameter of 6 or more inches and a length of 8 or more feet. A leaning snag that forms less than a 45° angle with the ground is considered a log. Most logs touch the forest floor, but sometimes they fall like jackstraws and are supported above ground by other logs (fig. 56).

Logs can be considered as either places animals forage or places that afford them protection. Insect-eating, fungus-eating, wood-eating, and predaceous animals find rich and varied sources of food in and associated with logs. Besides hiding cover and protection, logs provide physically complex structures where animals find stable temperatures and moisture for nesting, denning, feeding, and food storage. Logs also serve as places for sunning and as lookout posts. Spruce grouse (<u>Dendragapus canadensis</u>) regularly sit on logs sites where they are apparently better able to avoid predation. In spring, males use these elevated sites as walkways for their displays (Harrison 1996).

Small mammals use logs extensively as runways. This association between log structure and small mammals was apparent in studies of radio-tagged great gray owls. Nearly 80 percent of the time, down wood was within 3 feet of where great gray owls captured or attempted to capture prey (fig. 57) (Bull and

Henjum 1990). Maser and others (1979) described wildlife uses of logs in relation to log decomposition class, size, age, log species, and distribution. They described processes that lead to increased and more varied uses of logs by wildlife, plants, and invertebrates as logs decompose. Lofroth (in press) reviewed literature that further describes wildlife uses of logs, including log habitats under snow.

The size, distribution, and orientation of logs are more important to wildlife than are the tonnage or volume, as used in characterizing woody fuels (Maxwell and Ward 1980). In general, specific wildlife uses are correlated with log size. The smaller logs benefit small mammals, amphibians, and reptiles, for which they function primarily as escape cover and shelter when the animal can get inside or under the log (fig. 58). Large-diameter logs, especially hollow ones, also benefit a variety of other vertebrates like martens, minks, coyotes, bobcats, cougars, and black bears (Lofroth 1993; Lofroth, in press; Maser and Trappe 1984) (fig. 59). Hollow logs are used by black bears for winter dens in some parts of their range. During late summer and fall, bears forage for invertebrates in logs (fig. 60). What percentage of their diet depends on this resource is not known, although it seems to be substantial based on current studies in northeastern Oregon (Henjum and Akenson 1996). Research on fishers (Martes pennanti) suggests that up to three dens may be used in rearing a litter. Although most dens are in cavities high in large (36-inch d.b.h.) living or dead trees, large logs also are used. In California and Montana study sites, one den was in a 36-foot log that was large enough to provide a convoluted 12-inch diameter cavity through its length; another den was in a 59-inch log of white fir (Abies concolor) (Powell and Zielinski 1994).

Lynx (Lynx canadensis) select dense, mature forested habitats that contain large logs and upturned stumps to provide security and thermal cover for kittens. In north-central Washington, lynx den in Engelmann spruce/subalpine

fir/lodgepole pine stands with high densities of downed trees supported 12 to 48 inches above the ground, which provide structure and diversity for denning and hunting (Koehler and Aubry 1994).

Distribution of logs influences wildlife use. Trees sometimes die in clumps or patches from diseases, insect activity, or fire. Mortality of this kind ultimately results in aggregations of logs. Within relatively continuous forested stands, however, logs appear fairly regularly. In late- and old-structure mixed-conifer stands in northeastern Oregon, we found that densities of logs fell within relatively close ranges; that is, standard errors were 8 to 18 percent of the means. These stands were not randomly selected stands, however, but were associated with pileated woodpecker home ranges (Bull and Holthausen 1993, Torgersen and Bull 1995).

Amounts and distribution of logs in managed landscapes have varied effects on wildlife and management strategies. Too many logs may impede travel by deer, elk, and cattle; they also may present increased fire hazard (fig. 56). Large numbers of logs afford excellent cover habitat for small vertebrates (fig. 56). Heavy accumulations of down woody debris can increase seed losses and damage to tree seedlings by squirrels, chipmunks, and mice, but these accumulations do not necessarily result in such damage. Research suggests that seedlings may actually be protected from grazing and scorching by the physical barrier and shading provided by down logs. Such protection often outweighs the negative effects of increased habitat for rodents and problems associated with them (Dimock 1974, Maser and others 1979). Orientation of logs can influence wildlife use. Logs that lie along the contours of a slope may be used more by wildlife than logs oriented across contours, especially on steep slopes. Soil and organic debris that accumulate along the upslope side of a log encourage seedlings to establish and grow which, in turn, attracts invertebrates and small vertebrates that find more diverse structure and niches for activity (Maser and Trappe 1984).

Large numbers of down trees can form a maze of logs, many of which may be supported 2 or more feet above the ground by other logs. Patches of these jackstrawed logs often are found in late- or old-structured stands of lodgepole pine, Engelmann spruce, subalpine fir, and grand fir. Although such conditions may represent a significant fire hazard, they also provide critical structures for some animals. Marten, mink, and cougar hunt in them; when snow covers the logs, a complex array of snow-free spaces and runways provide important habitat for protection and foraging by martens, fishers, and small mammals under the snow. Tree squirrels also spend much of the winter in this environment, where they feed on seeds from cached cones.

Slash piles remaining after harvest can benefit some wildlife like rodents, hares, and rabbits (fig. 61). Increased commercial markets for chips and firewood have increased demand on this component of wildlife habitat. No completely researched guidelines exist for distributing logs and woody debris in managed stands. Although quantitative, spatial, and functional relations are still poorly understood, that does not make any single component or feature of distribution any less important (Bartels and others 1985, Maser and others 1979).

Decay Process

The decay of logs is continuous; some decay may begin even before a tree dies. The rate and patterns of decay and the decay organisms depend on many dynamic factors. Did the down log derive from a fallen snag or a living tree? If the log came from a snag, what killed the tree? How big is the log? Is it a long, small-diameter log or a short, large-diameter log?

Every living tree is composed of tissues that perform specific functions and have different structures to accomplish these functions. These tissue-substrates continue to provide different environments in logs over many

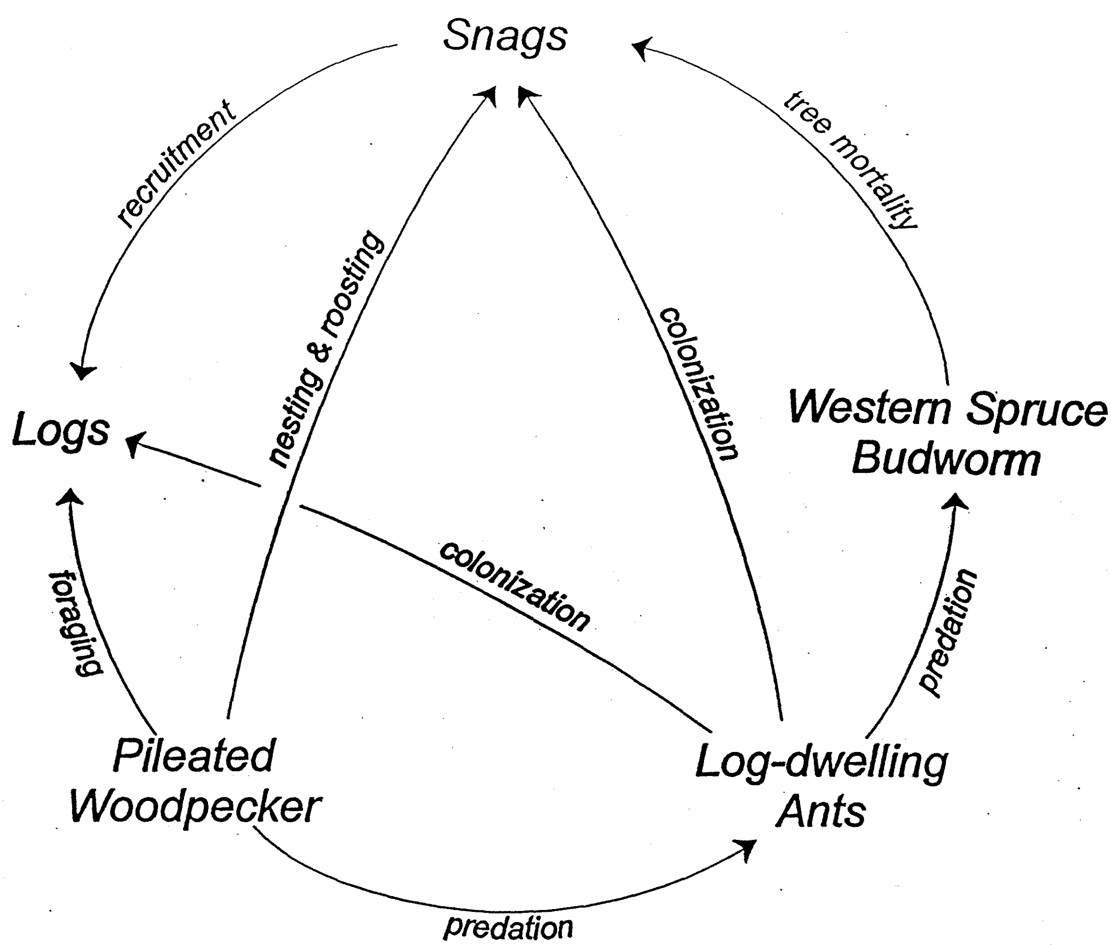
years for a host of microbes, higher plants, and invertebrates. The succession of decay-related organisms in turn produces a continuum of decayed wood with many different structural and textural characteristics.

Hollow logs are an example of a particularly important structural category. Logs do not become hollow on the ground; they are hollow because of the action of heart-rot fungi that occurred when the tree was alive. Such hollow trees ultimately die and fall to the forest floor (fig. 59).

The physical setting in which the log resides also affects the decay process. Slope, aspect, exposure to sunlight, elevation, and the degree to which the log is in contact with the ground all influence the characteristics of decay. Even orientation of the log can influence decay: logs that are oriented along the contours of a slope accumulate soil and debris against the uphill side, which holds moisture and hastens some decay processes. Charring of logs can hamper excavation by some invertebrates and vertebrates for many years, thus diminishing their wildlife habitat values even if such logs are well distributed and of large size (Maser and others 1979). The works of Maser and Trappe (1984) and Lofroth (in press) are excellent sources for more information on the dead wood cycle and terrestrial and aquatic life processes in logs.

The Log Resource

Size, species, and number of logs--These factors may be the most basic ones in describing the log resource in terms of its use by wildlife. Little information exists on the significant descriptive features for log resources. Appendix B provides a sample data form for inventories of the down log resource. Even determining the species of a decayed down log can be challenging, especially when some or all of the branches, cones, and bark are missing. Parks and others (in press) have prepared a field guide as an aid to



Functional relationships among key dead-wood structures, invertebrates and pileated woodpeckers.

identifying species of snags and logs of the interior Columbia River basin.

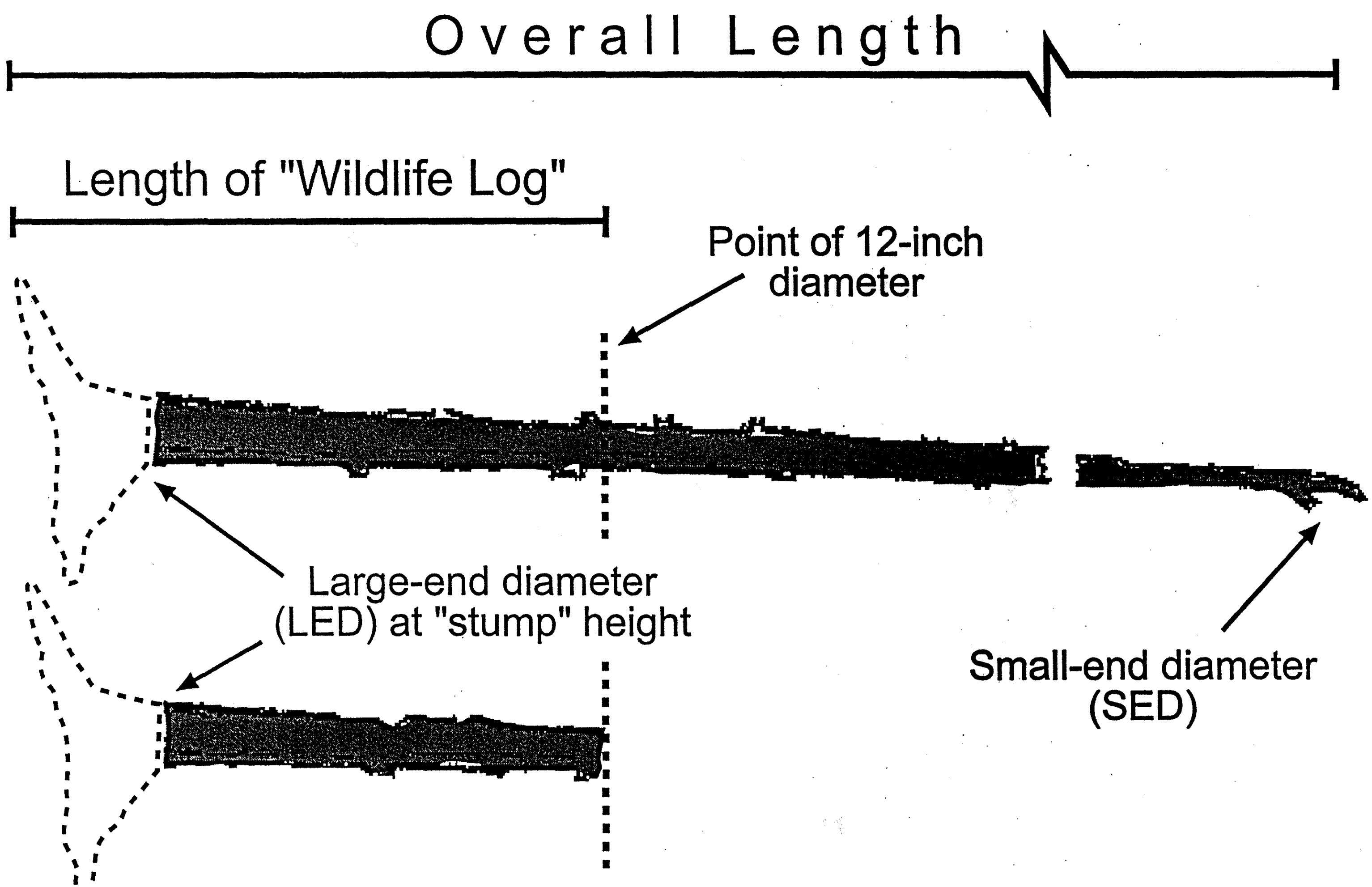
Bull and Holthausen (1993) found that in 38 percent of their observations of foraging pileated woodpeckers, the birds used Douglas-fir and western larch logs in mixed-conifer stands. Moreover, these birds favored logs that were 15 inches or greater in large-end diameter and in advanced stages of decomposition. A companion study to determine log characteristics that influenced the ant prey of woodpeckers showed the same pattern in occupation of logs by carpenter ants (Torgersen and Bull 1995), the primary prey of pileated woodpeckers (Beckwith and Bull 1985).

Determining whether wildlife use of particular logs is related to the species or to the size of the log is difficult. In studies by Torgersen and Bull (1995), lodgepole pine, which had the smallest mean diameters of logs, rarely supported populations of the wood-dwelling ants used as food by pileated woodpeckers. Conversely, western larch, Douglas-fir, and grand fir, which had the largest mean diameters, commonly supported these ant colonies. More specifically, the study determined that western larch logs were preferred for pileated woodpecker foraging and for colonization by wood-dwelling ants. Larch also had the greatest mean large-end diameters (13 inches) and represented about 14 percent of the logs, but their proportional use was far greater. Douglas-fir, grand fir, and ponderosa pine logs had mean diameters of about 12 inches and represented about 58 percent of the logs in the mixed-conifer study stands. Their use by ants and foraging woodpeckers approximated their representation in the total log resource. Lodgepole pine logs, however, which averaged only 9 inches in large-end diameter and represented 18 percent of the logs, were used much less than their representation among all logs. From the standpoint of ant colonization and woodpecker foraging, log size may be more important than species (Bull and Holthausen 1993, Torgersen and Bull 1995).

Descriptors of Log Resources

- Density (logs per acre)
- Large-end diameter (LED)
- Mean length of logs
- Total (combined) length of logs per acre
- Percent of ground covered by logs
- Wood condition (sound vs. rotten to calculate weight)
- Log structural class (bark, twigs, limbs, shape, portion on ground)
- Volume and / or weight

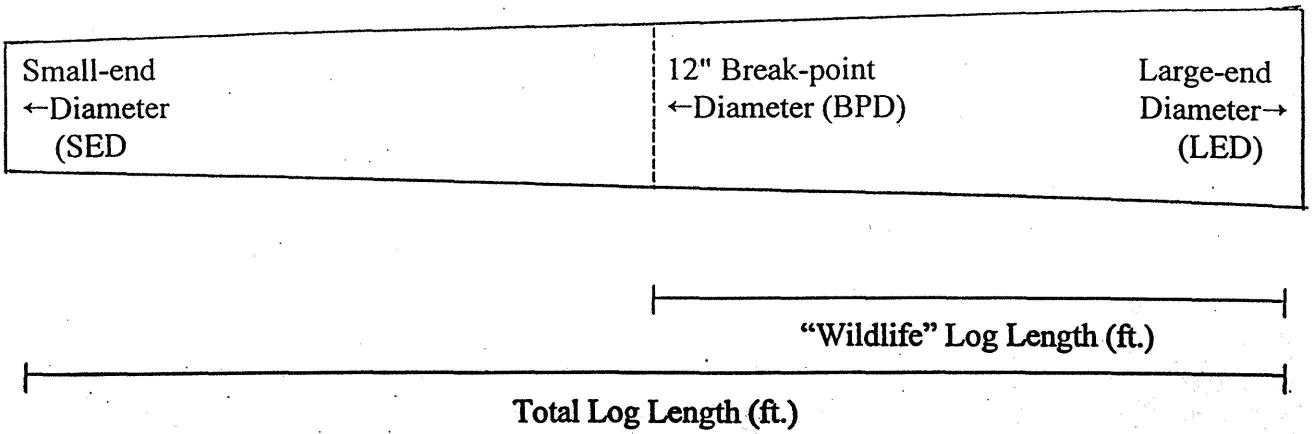
Descriptors of Log Dimensions



“Wildlife Logs”

- ≥12 inches small-end diameter
- ≥6 feet in length
- Expressed in pieces per acre
- Linear feet per acre

Linear Feet of "Wildlife" Logs



If SED is > 1 foot (12"); then "wildlife" length is equal to actual log length, in feet.

Any log whose LED is < 1 foot (12"), has no "wildlife" length.

If LED > 1 foot (12"), then use the following equation to calculate "wildlife" length for each log.

Note: All measurements in feet, including diameters; i.e. divide diameters by 12.

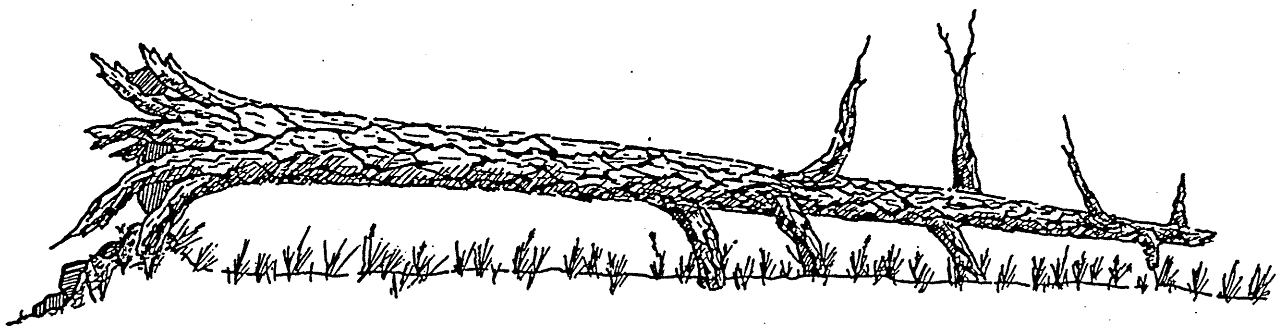
$$\text{"Wildlife" log Length (ft.)} = \text{Total Length} \left(\frac{BPD - LED}{SED - LED} \right)$$

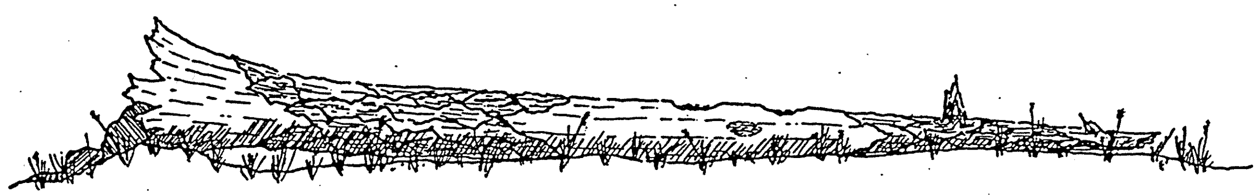
,where

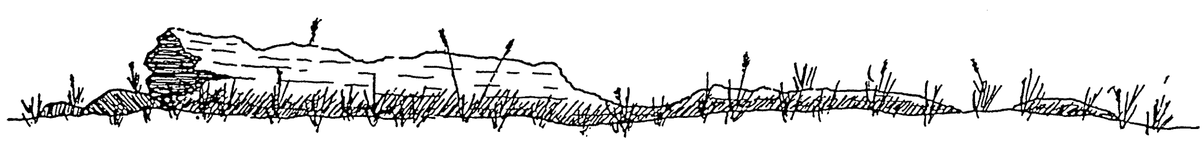
LED = Large-end diameter (ft.)
SED = Small-end diameter (ft.)
BPD = Break-point diameter (ft.)

Down Woody Material -- Log Structural Codes

Descriptor Code	Bark	Limbs	Wood Texture	Log Shape	Color of Wood	Portion on Ground
Code 1 Recent or Sound	Mostly intact	Present; some small branches	Mostly sound	Round	Original color	Elevated on support points
Code 2 Intermediate	Loose or missing	Mostly present	Sapwood decay present	Round	Original to faded	Entirely or mostly sagging
Code 3 Decomposed	Usually absent	Branch stubs loose	Heartwood or interior decay present	Round to Oval	Faded	Mostly or all on Ground







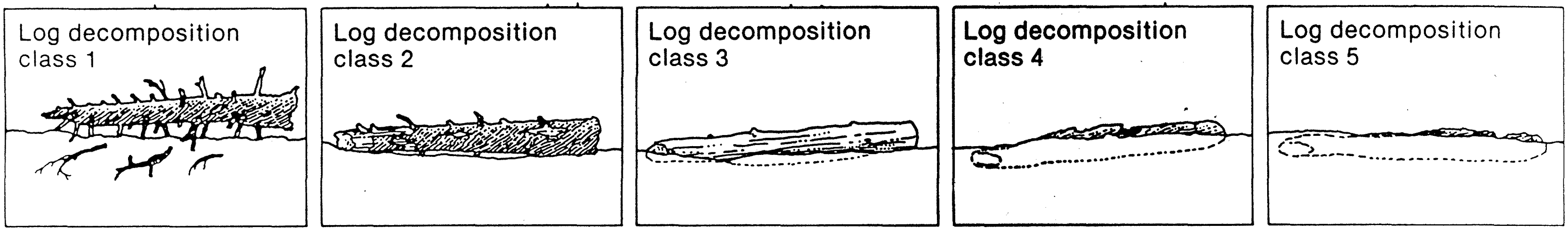


Figure 44. When they fall, trees and snags immediately enter one of the first four log decomposition classes.

Table 19. Snag condition translated into log decomposition class

Snag stage	Snag condition	Log class
1-3	Hard snag	1
4-5	Hard snag	2
5-6	Soft snag	3
7	Soft snag, 70% + soft sapwood	4

Log characteristics	Log decomposition class				
	1	2	3	4	5
Bark	intact	intact	trace	absent	absent
Twigs<3 cm (1.18 in)	present	absent	absent	absent	absent
Texture	intact	intact to partly soft	hard, large pieces	small, soft, blocky pieces	soft and powdery
Shape	round	round	round	round to oval	oval
Color of wood	original color	original color	original color to faded	light brown to faded brown or yellowish	faded to light yellow or gray
Portion of log on ground	log elevated on support points	log elevated on support points but sagging slightly	log is sagging near ground	all of log on ground	all of log on ground

Table 20. A 5-class system of log decomposition based upon work done on Douglas-fir (adapted from Fogel et al. 1973, used with permission, see also Minore 1966)

Another characteristic describing log resources is the length of logs. This is expressed as mean length of logs or total linear length of logs per acre. Data on lengths of logs in late- and old-structure mixed-conifer stands in northeastern Oregon indicate that for all species 6 inches or larger in large-end diameter, logs averaged 34 feet. Mean length for logs 15 inches or larger in large-end diameter was 47 feet. Among species for all diameter classes, ponderosa pine averaged the shortest (23 feet) and lodgepole pine the longest (45 feet). In these same stands, overall length of logs 6 inches or greater in large-end diameter was 2,064-4,928 linear feet per acre. Of this total, there were 175-602 linear feet of logs per acre 12 inches or greater in diameter. Logs in this latter size range are the stated size of logs for wildlife habitat in the Regional Forester's Decision Notice to adopt Eastside Forest Plan Amendment No. 2 (U.S. Department of Agriculture 1995). For mixed-conifer stands east of the Cascades, this Plan Amendment stipulates 15-20 logs per acre, 6 or more feet long, with a total linear length of 100-140 feet of logs 12 inches or greater in small-end diameter. The above limited data suggest that the target linear length stipulated in the Plan Amendment is considerably less than observed in 15 stands (Torgersen 1997).

Studies by Bull and Holthausen (1993) and Torgersen and Bull (1995) reported about 117 logs per acre in 12 late-structure mixed-conifer stands. In these studies, all logs that had at least 6 feet of their length in the 0.1-acre plots were tallied. This criterion resulted in a misleading density of logs per acre. Further interpretation of only logs whose midlengths fell within the 0.1-acre plots indicated that the actual number of logs per acre was 24 percent less than the total number of logs entering the plots. Thus, an average number of 88.8 logs per acre (standard error [SE] = 6.9) more accurately describes the true density of logs in the 12 home ranges of pileated woodpeckers in that study. Using the mean length of 34 feet per log translates to 3,026 linear feet of logs per acre in these home ranges.

Relationship of total log resources to "wildlife log" resources*.

	Logs ≥ 6" LED		"Wildlife Logs"	
Stand Type	**Number**	**Linear Feet**	**Number**	**Linear Feet**
Mixed-conifer	86	2064	24	440
Mixed-conifer	154	4928	15	175
Mixed-conifer	88	2375	32	602
Ponderosa pine	45	855	10	154
Old growth	113	3616	18	292

* Per Acre
Preliminary data; not for citation.

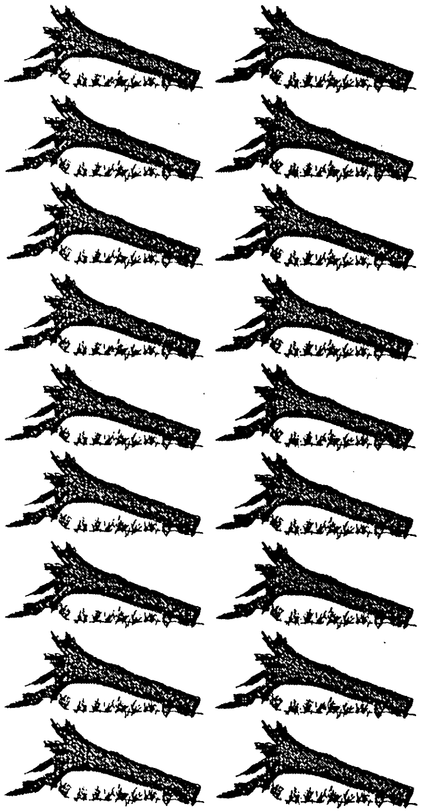
Observed wildlife log resources vs. guidelines* for mixed-conifer stands in "The Eastside Screens." **

	Logs per acre	Length (ft.)	Linear feet
Observed	15 - 32 ($\bar{x}$ = 22)	16	175 - 602 ($\bar{x}$ 377)
"Screens"	15 - 20	≥6	100 - 140

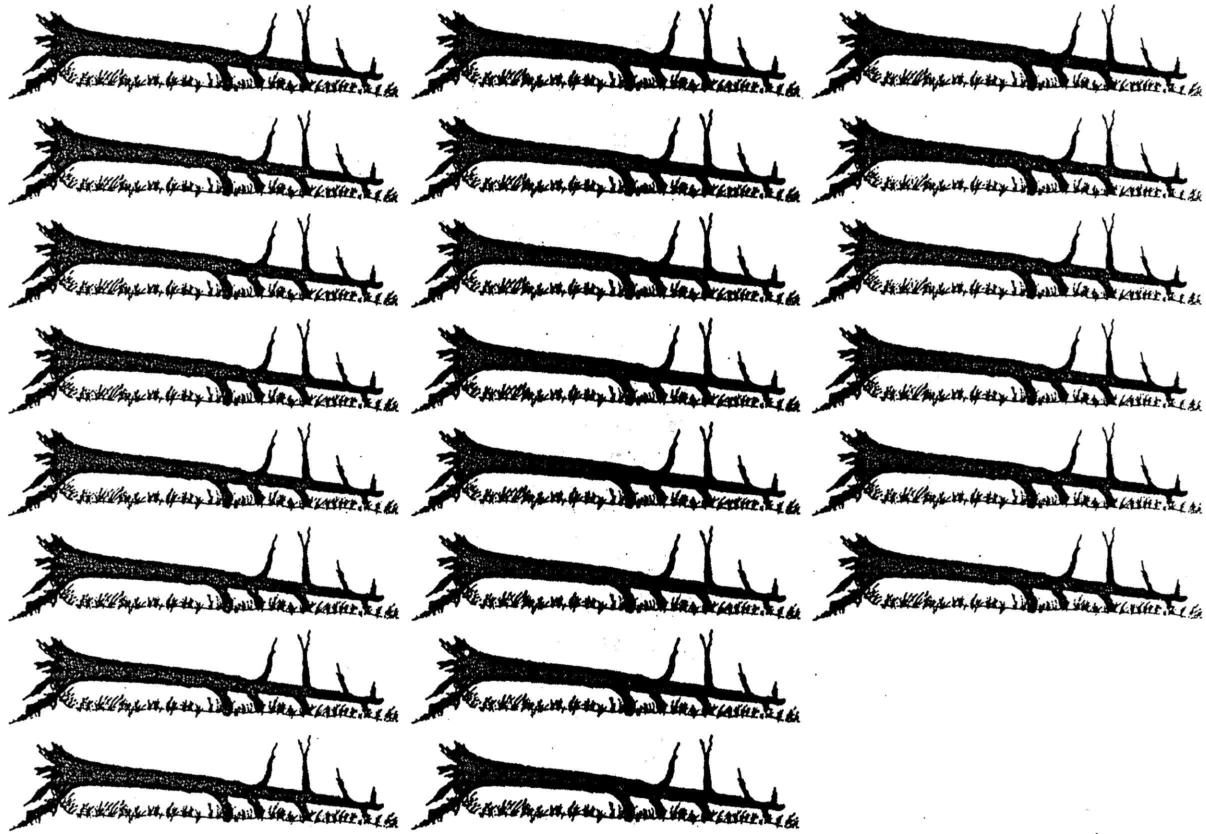
* Logs ≥ 12" in small-end diameter; i.e. "Wildlife logs."
** Preliminary data; not for citation.

Wildlife Log Resources

"Screens" vs. Observed



125 linear feet per acre
@ 7 feet per log.



350 linear feet per acre @ 16 feet per log.

Additional research in six stands of old-growth mixed conifers in northeastern Oregon showed an average of 92.9 logs per acre (SE = 11.9). Inventories in four stands of late-seral mixed conifers in northeastern Oregon showed an average of 88.5 logs per acre (SE = 14.5). The similarity in log densities among 27 widely distributed stands in four counties in northeastern Oregon suggest that log resources may be quite similar, about 90 logs per acre, in late- and old-seral stands of mixed conifers there (Torgersen 1996).

Inventories of logs in four ponderosa pine stands in northeastern Oregon that were selectively logged for the largest trees about 40 years ago show an average density of 45.5 logs per acre (SE = 8.3) (Torgersen 1996).

Studies conducted in coastal Douglas-fir forests west of the Cascade Range have used percentage of ground covered by logs as a feature against which to relate abundance of some small vertebrates and their food, particularly hypogeous fungi (truffles and trufflelike fungi) (Amaranthus and others 1994, Carey and Johnson 1995). Percentage of ground covered by logs has not been a habitat feature used to relate to wildlife in the interior Columbia River basin. We suggest that this feature may be a good one to include in assessments of down wood resources. Percentage of ground covered by logs can be calculated from the data we propose be collected in the log sampling form in appendix B.

Log structural classes--Logs may be in various stages of decomposition, from sound, newly dead trees, to logs that have deteriorated to the point of having nearly blended into the forest floor. Exterior appearance and interior structure differ among logs of various ages just as they do in living trees and snags. Maser and others (1979) classified logs by exterior appearance into log decomposition classes. In contrast, the physical properties of internal structure and wood soundness are here called "wood condition"--the extent to which the wood has become soft, friable, spongy, or pitted as a

Log resources* in selected stands in northeastern Oregon. **

Stand Type	Logs ≥ 6"	Logs ≥ 15"
Mixed-conifers	86	15
Mixed-conifers	154	5
Mixed-conifers	88	20
Ponderosa pine	45	6
Old growth	113	12

* Per Acre
** Preliminary data; not for citation.

result of attack by decay-causing organisms and channeling by invertebrates (Torgersen and Bull 1995).

The five log decomposition classes of Maser and others (1979) describe the physical appearance of deteriorating down trees. They characterized the classes by the presence or absence of bark and small twigs, the texture and color of the wood, the shape or amount of decomposition of the log, and the amount of contact of the log with the forest floor.

Unless evidence suggests otherwise, we suggest that three log decomposition classes are sufficient to classify the extent of degradation of fallen trees relative to most wildlife use. Thus we propose three log structural classes (figs. 62 and 63): log decomposition classes 1 and 2 of Maser and others (1979) are incorporated into log structural class 1, decomposition class 3 becomes structural class 2, and decomposition classes 4 and 5 become structural class 3.

Wood condition--Any examination of logs will show a range of external and internal wood conditions. Some logs may be almost uniformly sound or uniformly rotten; others may have sound heartwood but sapwood that has become crumbly as a result of colonization by fungi, beetle larvae, or ants. In northeastern Oregon sites, Torgersen and Bull (1995) used three wood condition classes (sound, moderately decayed, and advanced decay) to describe logs. Discriminant analysis suggested that this variable was only rarely related to either signs of foraging by pileated woodpeckers or presence of ants. Carpenter ants, the dominant prey of pileated woodpeckers, tended to be associated with sound wood, and more specifically with sound, large-diameter western larch.

Assessing wood condition is highly subjective but may be estimated by using a hatchet to chop into the log at intervals along its length. The butt end of a

log may be much softer than portions toward the small-diameter end. Because wood conditions vary in a log and because the sampling procedure is subjective, the relevance of wood condition to wildlife use is unclear. Nonetheless, we have included this variable on the sample data form for characterizing down log resources (appendix B). The decision to record wood condition is left to the user.

Hollow logs--Because of the exceptional values of this structural component to wildlife, we propose that this feature be specifically recorded in describing the character of log resources (appendix B).

Inventory of logs--Much study has been devoted to portraying amounts of down material as fire fuels (Fischer 1981a, 1981b, 1981c; Koski and Fischer 1979; Maxwell and Ward 1976, 1980). The breakdown into tonnages or volumes and the photo series for classifying forest residues, however, are of limited utility to biologists who want to describe log resources in ways that are relevant to use by wildlife. Management agencies already need estimates of log resources in stands to assure compliance with stated management goals in planning documents.

A survey of logs along transects and in fixed-size plots can be used to estimate numbers of logs per acre, species composition, and proportion of logs by diameter-class in selected stands (appendix C). The line transect method for assessing log resources was adapted from sampling techniques used to determine volume and tonnage of down woody fuels (Brown 1974, Brown and others 1982). A modification of this method uses 18 clusters of three 75-foot transects to characterize log populations in stands up to about 30 acres (Ottmar 1996). The fixed-plot method uses 18-20 circular or square 1/40th-acre plots to determine log populations in a 30-acre stand. See appendix C for detailed descriptions of these sampling schemes.

Information on numbers, sizes, and other characteristics of logs that produce suitable habitat for wildlife is scanty. The information given here is based on our research, which is limited to mixed-conifer stands in known pileated woodpecker home ranges (Bull and Holthausen 1993, Torgersen and Bull 1995) or data from other selected stands in the Blue Mountains of northeastern Oregon (Torgersen 1996). The management options offered above are based on preliminary information, and we anticipate that management will adopt different options as new information becomes available.

Review

- Size, species, and number of logs per acre are fundamental descriptors of the suitability of log resources for wildlife.
- Logs 15 inches or greater in large-end diameter are particularly important for species such as pileated woodpeckers.
- In mixed-conifer stands, logs of western larch, Douglas-fir, and grand fir were favored for foraging by pileated woodpeckers in northeastern Oregon.
- Late- and old-seral stands of mixed conifers have about 90 logs per acre in northeastern Oregon.
- Logs averaged 34 feet long in mixed-conifer stands in northeastern Oregon, but logs should be as long as possible to offer the greatest range in diameters.
- Hollow logs of any species and size class are important structural components to favor.